3.

PHILLIP'S

ON THE

POTATO DISEASE.

PLATE I. TRANSVERSE SECTION OF DISEASED TUBER

1. Bark.

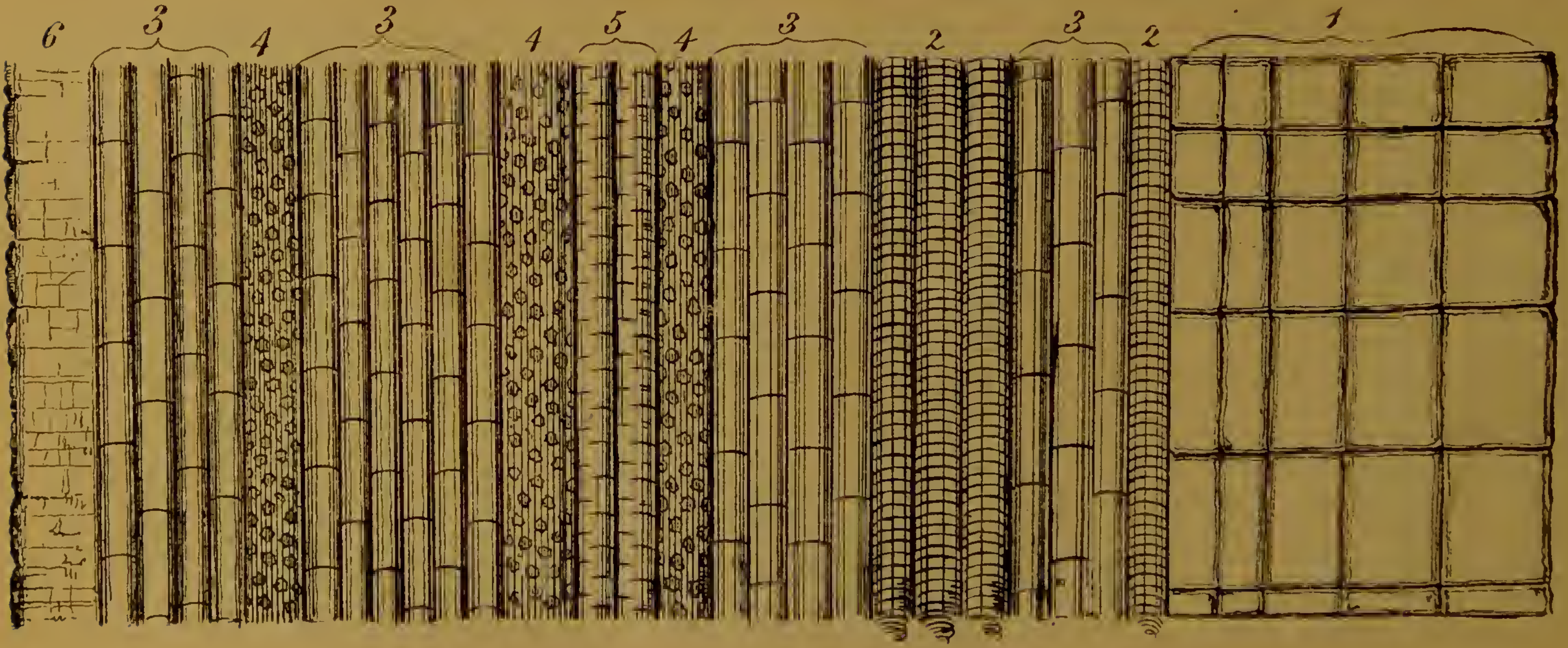
2. Cuticle.

3. Reservoir of empty cells.

4. Cells containing fecula.

PLATE 2. LONCITUDINAL SECTION OF THE STEM.

SEMI DIAMETER.



1. *The cellular texture of the medulla.*
2. *Spiral Vessels.*
3. *Vascular system with diaphrams.*
4. *Perforated Vessels with hexagonal perforations.*
5. *Annular Vessels.*
6. *Bark or epidermis*

PLATE 3. STEM WITH A SINGLE SERIES OF TUBER

TE 4. STEM WITH A CONTINUOUS SERIES OF PENDULUMS AND TUBERS.

THE POTATO DISEASE;

ITS

ORIGIN, NATURE, & PREVENTION,

WITH A

CHEMICAL AND MICROSCOPICAL ANALYSIS
OF THE SOUND AND DISEASED TUBERS.

BY

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PREFACE

This inquiry was commenced in order to to satisfy my own mind as to the nature and cause of the disease that has so generally attacked the potato in the present season, and not with a view to publish. I have been induced, however, to make known the results of my labors, and should any good be effected in consequence, I shall be happy in the result thus attained. The conclusion I have arrived at with regard to the origin of the disease is such as the facts I have elicited appear to justify, and which the mind, upon a careful consideration of them, seems naturally to adopt.

The evidence, however, upon which this opinion is based is submitted to the public, and it will be for them to judge whether I have arrived at a just conclusion or not.

This publication would have been better arranged and made more complete had time permitted; but the disease is spreading, and I have therefore hastened the appearance of the work, in order that if it contain anything useful, it may be made available without delay

4, Upper Park Street, Islington,
November, 13th, 1845.

CONTENTS.

CHAPTER I.

SOUND POTATO.

ANALYSIS OF A WHITE KIDNEY POTATO RAISED FROM THE SEED.

The tuber was taken from the ground October 2nd, 1845, at 7 o'clock A.M. and the amount of water it contained immediately ascertained, and the analysis commenced the same evening.

100 PARTS CONTAINED

Water	75·700
Starch, pure and very white	15·880
Sugar	0·666
Potateine and coloring matter	1·780
Gum	1·260
Albumen	2·160
Ligneous fibre	1·370
Silica	0·003
Alumina	0·101
Lime	0·088
Potash	1.010
Magnesia	A trace.
Sulphuric Acid	A trace.
Chlorine	0·062
Total	100·080

In the substance that I have named Potateine resides

the aroma and flavor of the potato; and when a potato is divested of its potateine, it is flavorless and has no characteristic by which it could be distinguished.

Potateine may be procured in the following manner: Wash a potato quite clean, and wipe it dry; grate it so as to form a pulp, digest in alcohol of a density 825° or 828°, using at least half-a-pint to 3 oz of potato. After it has digested 3 or 4 hours, and been frequently stirred, filter and distil off the alcohol to one-fourth or less; evaporate the remainder to dryness in a water bath, and the potateine containing coloring matter will be re-covered. Potateine, in the state in which I have procured it contains potash, and probably solanine. I have not however had time to investigate its properties generally, but from its character, I suspect it will be found to contain a large proportion of azote as a constituent.

The analysis of the potato shows it to contain a quantity of water—equal to three-fourths of its entire weight. This amount of water is not much lessened, even when the tuber is boiled, and prepared for the table in a mealy and apparently dry state

The following experiments on the raw and cooked tuber show the amount of water each contained:—Raw white regent potato washed and wiped dry!—

100 PARTS CONTAINED

Water	78·0
Dry Potato	22·0
	100·0

The same potato boiled, and in the state as served at the table.

100 PARTS CONTAINED

Water	75·3
Dry Potato	24·7
	100·0

Diseased white potato—The parts selected were fetid, and varied in color from yellow to brown and black.

100 PARTS CONTAINED

Water..	79·0
Dry Potato	21·0
	100·0

The appearance of a cooked and raw potato is very different; and were we to infer the amount of water contained in each by its external character only, we should in all cases decide in favor of the raw one. The appearance, however, is deceptive and not to be relied on; for experiment proves that in dressing the tuber for the table by boiling, it loses but little of the water due to it in its normal condition. The change of appearance produced in the potato by the ordinary process of cooking is sufficiently accounted for when the constituents and construction of the tuber are considered.

The great mass of the tuber is cellular tissue filled with granules of starch floating in water, gum, sugar and albumen. When heat is applied to the tuber, the starch granules expand, and as the heat approaches to 150° Fahrenheit they enlarge by the absorption of cel-

lular water. This enlargement partly arises from incipient gelatinization, and partly from the permeation of the water between the ultimate atoms of starch that form the full-sized granules observable in the cells. The large granules of starch are made up of minute or ultimate atoms by the attraction of aggregation, and the repulsive action of heat separates them into smaller ones*. Consequently the separation, expansion, and incipient gelatinization of the granules secrete the water from the eye of the observer, by presenting to it a rough surface, studded with myriads of minute granules that sparkle like diamonds, and which microscopically are beautiful objects to behold†

The analysis of the potato fully bears out its value as an article of food. Thus we have starch, gum, sugar, and albumen,—all of them important edible substances and without which animal life could not exist. The three first-named substances contain carbon and water, water being composed of oxygen and hydrogen; albumen contains in addition to these elements azote or nitrogen; and azotized bodies are necessary to the support of animal life. The elements, carbon, oxygen, and hydrogen perform important functions in the animal economy. The heat of the system being kept up by the combinations they effect while in it. Carbon and oxygen form carbonic acid, hydrogen and oxygen, water; and in the formation of these two compounds heat is deve-

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* Under the head of the Formation of Starch Granules chap. IV. p. 22 this subject is treated of more fully.

† These observations with respect to the separation of the granules apply whether they be vesicles or otherwise.

loped, and the animal temperature maintained. Carbon and water alone could not support the system because they would be breathed and transpired away in the form of carbonic acid and water, and the organs of the animal being unsupplied with food fitted for their formation would languish and die. Another substance is therefore necessary, and that substance is nitrogen—a constituent of the azotized principle of the potato albumen.

The potato, therefore, is an important and valuable edible ; it presents to man constituents necessary to his well-being, and without which he would cease to exist.

CHAPTER II.

DISEASED POTATO.

The diseased potatos were from the same ground as those used in the first analysis on page 7. They were of the same kind, and raised from the same seed. The parts selected were soft and pulpy, the organization of the tuber being completely destroyed. In color, the diseased portions used were yellowish drab, snuff brown and black. The mass thus selected had a very unpleasant fetid odour.

100 PARTS CONTAINED

Water	78·20
Starch impure and of a brown color ..	16·00
Sugar	None
Potateine and coloring matter	1·20
Gum	1·40
Albumen	0·60
Ligneous fibre	1·20
Silica, Alumina, Lime, Magnesia, Potash, Sulphuric acid and Chlorine ..	1·20
	99·80

I suspect the sound tuber contains a small quantity of acetic acid, but this, as well as its amount, and that of the ammonia in the diseased tuber, I have not had time to ascertain.

The analysis of the diseased tubers afforded as much starch as the analysis of the sound ones. The starch, however, was rather dark colored, but perfectly sweet and good. It appeared as fit for food, and as nutritious as the white starch of the sound tubers, and color excepted; I have no doubt it was intrinsically as valuable. The dark color of the starch proceeded from minute fragments of finely divided fibre, derived from the disorganization of the cellular tissues.

The analysis of the sound and diseased tubers present certain differences; these differences I propose to examine, and from thence draw certain inferences, in order to prepare the way for that chapter which I propose to devote exclusively to "The Origin and Nature of the Disease."—(*See chap. VII., p.* 38.)

The water in the diseased tuber exceeded that found in the sound one by $2\frac{1}{2}$ per cent. To this circumstance, however, I attach no weight, because we find on reference to page 8, that a healthy potato will afford 78 per cent. while that of the diseased is only 78·2 in one case, and 79· in another. The water therefore I consider variable and dependent on the nature and kind of tuber, rather than an effect of the disease. The amount of starch exceeds that of the sound tuber by 12-100th parts,—an approximation so close that we may, for all practical purposes, consider them the same. Indeed the probability is, that they were so; because the slight impurity of the starch derived from the diseased tubers would throw an excees of weight on that head equal to the amount of foreign matter it contained. The sugar has disappeared, the potateine, and coloring depreciated 58-100 or rather more than $\frac{1}{2}$ per cent. the gum slightly increased, the albumen decreased nearly $\frac{1}{3}$, and the ligneous fibre slightly depreciated. To the increased weight of the starch we may attribute the slight depreciation of fibre; the loss of albumen to the generation of ammonia; the depreciation of potateine and coloring to the potateine being an azotized body, and subject to the same decomposition as the albumen; the total disappearance of the sugar to its conversion into gum, and subsequent decomposition. From the nature, of the changes that have been noticed, both with respect to the amount and character of the various substances acted on, I draw the following conclusions:—

First.—The change that takes place in the constituents of the potato is purely chemical.

Secondly.—The chemical action is proximately induced by the decomposition of azotized matter.

Thirdly.—That no decomposition of the starch takes place, even though the tuber be reduced to a soft pulpy mass, varying in color from yellow, to brown and black, and emitting a fetid and disagreeable odour.

The primary cause of the disease I shall leave untouched, until I have passed through chaps. III. IV. V. and VI. when I intend to devote chap. VII. to that object. This course appears necessary, because I shall then have given experiments confirmatory of the view I have taken of the subject; and also a series of microscopical observations, with plates illustrative of the subject.

CHAPTER III.

RE-AGENTS, ACTION OF.

Slices of a white potato were used about a quarter of an inch in thickness; the potato was placed on white glazed tiles, and the re-agents added to it cold. After the lapse of 12 hours the action was noticed. No heat was subsequently applied.

Potash.—Caustic—solution of a moderate strength. The potato black in some parts, and of a brown

color, in others through its entire substance. The upper surface to which the potash was applied dissolved or gelatinized, the under surface not gelatinized, and of a deeper black and brown color than that of the upper; bark and cuticle not changed. The black spots opaque, and the brown ones slightly so. The under portions of the potato not softer than when a slice is exposed to the action of the atmosphere without the intervention of any other substance.

Soda.—Caustic.—Action the same as that of the potash.

Ammonia.—Same as potash and soda, but not so intense, and no gelatinization observable.

Iodide of Potassium.—Similar to ammonia.

Chloride of Potassium—Applied in crystals.—Reddish black through the entire substance of the potato, the color deeper in some places than in others, dark spots opaque, potato soft. Potato immersed in solution; no change of color but softened.

Chloride of Sodium.—Or Common Salt.—Color brownish drab through the substance of the potato, the bark and cuticle darkened. Potato not softer than when exposed alone to the air. Potato immersed in solution, became rather black on the uppermost part, other parts not affected. Very soft, after being four days in the solution.

Chloride of Calcium.—The starch of a dirty drab color, with dark brown spots here and there through the depth of the potato; bark and cuticle of a natural color. Potato not so soft as when exposed alone.

Prussiate of Potash.—Yellow.—Potato dull yel-

low through its substance, the under surface rather brown. Potato soft.

Phosphate of Soda.—In Solution.—No change of color ; the potato not softer than when exposed to the atmosphere alone.

Bicarbonate of Soda.—Similar to chloride of potassium.

Sulphate of Soda.—Potato of a blackish brown color, skin darkened. Not softer than when exposed alone. Immersed for four days in a solution, no change of color, but rather softened.

Sulphate of Alumina and Potash, or Alum.—The potato of a light straw color; bark and cuticle unchanged. Potato hard and firm.

Sulphate of Iron.—Proto.—The potato yellowish brown through its entire substance; iron per oxidized in parts of it, and the potato soft.

Sulphate of Copper.—The fecula stained through the whole mass of the potato of a bluish green color. Softness natural.

Iodine.—Tincture.—Potato blackened on its upper surface only, and that superficially. The potato firm.

Tannin.—Potato yellowish brown in color through its substance, and very firm and brittle.

Sulphuric Acid—Dilute.—Potato bleached; the bark, and cuticle, and also the fecula for about the 1-8th of an inch inwards tinged of a light crimson color; the color gradually lessening as it approached the centre, until lost in the white of the starch. Potato soft but not pulpy.

Hydrochloric Acid.—Concentrated, pure.—Fecula

bleached; the bark and cuticle, and a portion of the starch near to it, of a faint pink color. Potato soft as pulp.

Nitric Acid.—Concentrated.—Potato of a straw color through its entire substance; bark and cuticle ighter colored, and the potato pulpy. The same acid ilute, tinged, the skin, and also the fecula for about he 1-8th of an inch inwards of a crimson color. It leached the other parts, but rendered the potato soft nd pulpy.

Oxalic Acid.—The fecula yellowish white, skin nd a small portion of the starch inwards a faintish ink.

Tartaric Acid.—Fecula white, the skin and a ortion of the starch inwards, tinged pink; the potato ot softer than when exposed to the air, without any -agent.

Nitrogen.—The potato was exposed to the action of e gas for 40 hours in a tube standing over water; at e expiration of that time it was examined. When amined, it was found to have undergone no change hatever. The color was the same as when first aced in the tube, and it was as crisp and full of ater as when first cut for the experiment.

Oxygen.—Potato cut and fitted in a tube that held out one pint measure. The cut potato arranged so to allow the gas to enclose it on all sides. After anding for 48 hours, examined. The potato dry on s surface, the fecula appearing in granules; the terior of a brown color. In some places where the tato was broken by pressing it in the tube with a

glass rod, the color was chocolate; a small portion of the gas absorbed. The potato not softened, and the brown color only superficial in depth. The bruised parts dark in color to one-third of an inch in depth. The gas possessed the properties of oxygen, after the potato had stood in it 48 hours.

Carbonic Acid.—Potato cut and treated as with oxygen.—No change of color except in the parts bruised by the rod, which were of a dark brown color. Not dried. The potato absorbed about three times its volume of the gas in 48 hours.

Hydrogen.—Potato treated as with oxygen and carbonic acid.—Surface dry, the fecula appearing in granules; no change of color; the potato not softened. The gas possessed the properties of hydrogen at the end of the experiment. Not absorbed.

Ammonia.—Concentrated.—Potato cut and placed in a close tube, and exposed to the vapor of ammonia for 20 hours; no change of color. The potato was then immersed in the ammonia while yet in a close vessel, and after standing 48 hours, examined. No change of color; the potato not gelatinized, but rendered soft and cheese-like in feel.

Potash.—Concentrated solution.—Potato cut and immersed for 48 hours, then examined. Partially dissolved; the color a faint yellow.

Soda. — Concentrated solution. — Treated in the same manner as with the potash. The results the same.

A sound potato is acid, a diseased one alkaline.

If a potato be cut and exposed to the atmosphere

the cut parts become brown after the lapse of a few hours, and if a mass of grated potato be placed in an open vessel, and left exposed to the air, it undergoes the following changes :—

First.—The surface, in a short space of time, becomes drab, then reddish brown, and at the end of 48 or 50 hours, a black color.

Secondly.—At the end of half an hour or so it emits an odour very much like olive oil. In two or three days it becomes fetid. The temperature of the atmosphere in which it was placed was about 62° Fahrenheit.

Thirdly.—When first collected, it is acid; but after standing, it becomes alkaline.

On looking over the results of the re-agents applied, we find that the alkalies aud some of their salts produced a black and brown color, while the potato was exposed to the atmosphere; but when immersed in a very concentrated solution, no such effect was perceivable, the potato then being out of the influence of the atmosphere. The acids generally bleached and softened the potato. Solutions of chlorides of sodium and potassium, and sulphate of soda were made, and the potato immersed in them: no change whatever ensued ; but when these substances were applied under the influence of the atmosphere, considerable changes in the appearance were effected: nitrogen, hydrogen, and carbonic acid affected not the color, but oxygen did. The atmosphere is composed of oxygen and nitrogen with a minute quantity of carbonic acid ; and as nitrogen and carbonic acid produced no change of

color, it must necessarily be the only remaining element—oxygen that did.

The presence of oxygen, therefore, seems necessary to the production of the color, and it may be attributed to it. The production of color by the oxidization of certain substances is well known, an instance of which is indigo. Deoxidize the blue indigo of commerce, and the color is gone ; restore to it oxygen, and the blue color appears again.

The brown coloring matter observable in diseased and cut potatos I consider attributable to the oxidation of the coloring principle, which thus renders it evident to the senses. It is therefore an effect of the disease caused by the presence of oxygen liberated by the decomposition of the substances shown in the analysis. The disease would therefore continue its progress were no coloring matter present, without presenting any phasis, except the softness of the tuber, by which it could be distinguished. The color is then an index that warns us of the disease,—a safeguard that is valuable in the hands of the careful and prudent, for it presents itself in a form that cannot be mistaken the instant the disease has commenced.

BEHAVIOUR OF REAGENTS WITH POTATEINE.

Reagent.	Whether soluble or not.	Color.
Nitric acid, conctd.	Soluble	Pale yellow
Hydro-chloric, do.	Ditto	Deep brown.
Sulphuric, do.	Ditto	Ditto
Ditto, dilute	Partially soluble but turbid	Pale straw.
Oxalic, concentrated	Ditto	Ditto
Tartaric, do.	Ditto	Ditto
Ether	Soluble	Ditto
Alcohol	Ditto	Ditto
Water	Ditto	Dltto
Ammonia, concentd.	Partially but turbid and flocculent.	Ditto
Potash, do.		Ditto
Soda, do.	Ditto	Ditto
Ammonia carbonate	Ditto	Ditto
Soda bi carbonate	Ditto	Ditto
Ditto phosphate	Ditto	Ditto
Potash, red chromate	Ditto	No change.
Do. yellow prussiate	Ditto	Ditto
Lead acetate	Insoluble	Coloring precipitated and a white flocculent matter with it.
Iodine solution	Partially soluble	No change.
Copper sulphate	Ditto	Green.
Cobalt nitrate	Nearly soluble.	No change.
Zinc sulphate	Ditto	Ditto
Iron per oxide	Ditto	Color deepened.

CHAPTER IV.

STARCH GRANULES.

WHERE FORMED, THEIR SHAPE, NOT ATTACHED TO THE WALLS OF THE CELL, BUT FLOAT IN THE LIQUID CONTAINED IN THEM.

The granules of starch may be traced from the medulla of the stem downwards, through the string or pendulum, into the tuber. The size of the granules in the pith of the stem do not generally exceed ·0006 of an inch in diameter, and descend as low as the ·00002. A transverse section carefully prepared shows them to advantage; a longitudinal one is improper, as it cuts through the cell and distorts their appearance by breaking the tissues. Although the granules of fecula may be traced from the stem to the tuber, we are unable to say, by observation, whether they are carried down to the tuber by mere gravitation, floating as they do in water, containing albumen, sugar, gum, &c., or by some action of the vessels answering to that of muscular in animals. All that appears certain on the subject is, that they are elaborated in the leaves and stems, and afterwards conveyed to the tubers, and deposited in the cellular tissues. Plate 2 represents a longitudinal section of the stem, in which we find six

different forms of vessels to exist. The fecula, however, is only found in the cells of the medulla marked 1, and not in any of the other vessels by which the pith is surrounded. In the cells of the medulla no arrangement can be discovered by the highest power the microscope affords, for the transmission of the fecula to the tubers. All that can be ascertained is, that the cells transversely have a membraneous covering, and longitudinally, in addition to this membrane, there are two tube-like vessels that run between the membranes of each cell, and circulate around them. I have never discovered any fecula in the vessels between the walls of the cells, but I have ascertained that these vessels have no diaphrams, but are continuous and unbroken.

The form of the fecula is oval, and so true and beautifully formed are they, that they present a very pleasing microscopical object. To ascertain the shape in which the granules exist in the cells of the tuber, a transverse section must be made by cutting perpendicularly to the pendulum, taking the centre of the tuber for the part selected. It is essential that the cutting be very thin, otherwise indistinctness and confusion will arise by the refractions of light in passing through the numerous vessels and granules to the eye. The cutting that will show the true form of the fecula, will also show how they exist in the cells. Having satisfied ourselves as to form, we may satisfy ourselves as to the mode of existence, thus—place the glass on which the cutting rests in an oblique position on the holder, and with the foci arranged and the eye intently

fixed on a particular cell, tap gently the object holder to which tbe cutting is secured. The motion thus imparted to the holder will agitate the cellular water, and the current produced by this action will carry in its stream the granules we are observing, and they will be seen to float in the water of the cells. The floating of the fecula proves their independence and freedom, consequently they have no hilum, duct, or any point of attachment, but are, in all respects, free to move within their respective cells by means of the liquid in which they exist. The number of granules in the cells vary,—some cells containing 60 or 70, others from 200 to 300. The size also varies—some containing 130 times the solid contents of others. The size of the largest granules in the cells is about ·0046 of an inch in diameter while others are no more than ·000024. The largest are always found in the cells that surround the centre of the tuber.

Plate 1 represents a transverse section of the tuber highly magnified; the fecula is secreted only in the cells marked 4. In the part 3 are cells nearly formed but empty; these cells are elaborated for the enlargement of the tuber, and stored ready to be used as receptacles for the fecula when wanted by the tuber for its own increase. The cells in the centre are filled first, then those adjoining, and so on through the progress and growth of the tuber. Consequently in the development of a tuber, the germe starts with the arrangement shown in the plate 1. The part marked 2 I have denominated the cuticle, bnt this in reality is composed of tubes that run continuously between the walls of the cells through the

vhole tuber. This cuticle therefore is a tubular struc-ure prepared for the circulation of the secretions and o build up the walls of the cells, of which it becomes part as the tuber enlarges. Very great care and good nanipulation are necessary to get a cutting that will show the arrangement of the vessels transversely; for is the potato contains a large amount of natural water, t happens that when the cells are dissevered, the fecula loats in the liberated water that rushes over the sur-face of the cutting, and deposits itself in the cells of the resorvoir 3, and even on the cuticle 2. To pro-cure therefore a cutting fit for the purpose of viewing the vessels transversely, the tuber should be quarter-ed, and a part selected from the centre. The trans-verse cut should be made perpendicular to the direction of the string or pendulum. The cutting should be very thin, and made at one stroke commencing from the skin, and striking inwards. The tuber selected for the cutting must be fresh and contain its natural amount of water.

Note.—Starch granules by measurement with a power of 150 diameters and a diaphragm, the 25th of an inch in diameter were as follows:—

Largest Size.

Length of oval............ ·00468 of an inch.

Breadth ditto .... ·00234 do. or exactly half.

Smallest Size.

Diameter .... ·0000244 of an inch.

CHAPTER V.

MICROSCOPICAL AND OTHER EXAMINATIONS.

THE STEM, THE STRING OR PENDULUM, THE TUBER—A DISEASED TUBER—THE COURSE OF THE DISEASE IN THE TUBER, WHERE THE DISEASE COMMENCES.

The stem of the potato contains a very complicated arrangement of vessels, a description of which may be seen in plate 2, which represents a longitudinal section. To the inferior or lower part of the stem the root is attached; from the stem and also from the roots strings or pendulums are thrown out. These strings or pendulums attach the tubers to the stem, and convey to the tubers the juices elaborated by the vessels of the plant, and are the only channels of communication for the formation and support of the tubers. The size of these strings vary from about 1-20th to that of rather more than 1-12th of an inch in diameter; their length also varies from 2 to 10 inches. Some of these strings are found perfectly smooth through their entire length, while others throw off rootlets or fibres, by which they attach themselves to the soil. In some plants, a single series of strings and tubers only exist; in others, a continuous

series, as shown in plates 3 and 4. Plate 3 represents a single, and plate 4 a continuous series.

A very thin transverse section of the string or pendulum shows the vessels to contain cellular tissue, like that of the stem. The epidermis, however, is different, being composed of horizontal tubes diverging from the centre, and which in this section appear separated by diaphrams, but when seen in a longitudinal one, are discovered to be continuous tubes.

A longitudinal section shows the same kind of vessels as are seen in the stem, with the exception of the spirals.

The perforated vessels are hexagonal in their perforations, as are also those of the stem; and in both instances they are similarly arranged. It is singular that the perforations in these vessels are in the form of some of the cells of the tuber,—a circumstance that might incline one to think they had a control in the formation of the cells, and the conveyance of the starch granules into them. But all my researches on this head have produced no satisfactory result, the extreme minuteness of the vessels rendering an examination of them very difficult and uncertain. The average size of the perforated vessels in the string are, ·0024 of an inch in diameter, and that of the perforations ·0004 while the vessels that circulate between the walls of the cells are only ·0008 of an inch in diameter. The arrangement of the vessels in the tuber is shown in plate I, and as they have been described in chap. IV. it is not requisite to explain them further.

Where an eye or germe is formed, the medulla of the string passes through the tuber, spreading itself out to

the part of the cuticle where the eye afterwards appears in the bark. In a transverse section of the tuber, the course of the medulla in the formation of the eyes may be traced by light colored straw or very pale yellow streaks surrounding a white cellular mass. This character may be seen in all those parts of the tuber that lead to the eyes, and also in those that lead to the strings. At the nucleus of the eye, the substance of the potato presents the following appearance when viewed by a power of 150 diameters, and the cutting not sufficiently thin to allow the light to pass through it. The eye or germe appears arranged in a semi-oval or horse-shoe form, and surrounded, except at the ends, by two stripes of a dark brown color ; the semi-oval, is also brown. Between the semi-ovals and the brown stripes that surround it, channels of a light membraneous structure exist, in which float myriads of of starch granules. So numerous are the granules in these channels and the parts surrounding them that they float past the eye of the observer in shoals. The fecula in the germe and the parts adjoining it, are generally very small, and there is no appearance of cellular structure or any kind of vessels in the germe and the parts immediately surrounding it. If we now make a very thin longitudinal cutting, we shall perceive that the germe is composed of longitudinal, (3,) perforated, (4,) and annular vessels (5, plate 2.) These vessels may be traced from the pendulums to every part of the tuber where an eye or germe is formed.

If we cut a tuber transversely and perpendicular to the pendulum, we perceive a dark yellow or bright colored

ing traversing the whole of its substance: this ring is :omposed of annular, perforated and longitudinal vessels. f we trace this ring up to the pendulum, we find its rigin to be from thence; and if we carefully examine he pendulum and the tuber at their juncture with each ther, we further find that the vessels of the pendulum livide themselves and take different directions. The ellular (1 plate 2) forming the pith or medulla in which he starch is secreted, and 6, the bark follow the periphery or outward part of the tuber, 3, 4, and 5 form the ark colored ring in the substance of the tuber. When a endulum and germe are formed, the vessels 3, 4, and 5 ush themselves to the cricumference of the tuber, and neet the vessels, 1 and 6, with which they unite. lthough I have not discovered the spirals (2 plate 2) in e pendulum and tuber, yet they must necessarily be ere, and I have no doubt may be found among the ssels 3, 4, and 5.

Plate 1 represents a transverse cutting of a diseased ber. The disease always commences at the cuticle and takes a direction towards the centre of the tuber. passes through the resorvoir of empty cells 3, to the lls containing the fecula 4, by means of the vessels at circulate between the walls of the cells and also by e vessels 3, 4, and 5, plate 2. As the disease advans, the cells become filled with an opaque brown loring matter. This coloring matter in no way inres the starch granules, but merely forms a coating their surfaces, and the starch will remain perfect en though the tubers be pulpy and fetid,—disgusting ke to both sight and smell.

The walls and vessels of the cells, being the most fragile and delicate in their texture, are the first that become disorganized and broken up. The constituents of the potato as shown, in the analysis, then become affected, and the evil rapidly extends unless checked by some such means as are hereinafter stated.

The outward appearance of a tuber is no indication of its soundness, for the disease invariably commences in the cuticle of the string or pendulum at the part where it joins the tuber. If a potato be diseased at all, (unless by some external injury,) it may be known by cutting a transverse section at and perpendicular to the pendulum. The cutting should be made immediately below the bark or outward skin, and if the tuber be diseased, a brown spot will be seen, more or less extended according to the severity of the disease, and the length of its duration.

Some tubers have 2 or 3 pendulums formed in them, at either or the whole of them combined, the disease may therefore commence. A string or pendulum in single tubers may generally be distinguished from an eye by its seat, being less sunk in the tuber, and the surface around it being free from sprouts or germes. In continuous tubers sprouts will sometimes appear around the hollow of the pendulum, but a little experience will enable a person to distinguish the one from the other. Germes and pendulums that are perfectly sound, have a ring or speck of a yellowish brown color immediately beneath the cuticle. This speck or ring, (for it presents either as the cutting is made,) arises from a condensation at those parts of the vessels 3, 4,

nd 5, plate 2. In the formation of a germe and pen-ulum, these vessels spread through the cellular tissue f the tuber, and connect themselves with those mar-ed 1 and 6, plate 2, at the cuticle; and thus where-er a germe and pendulum are formed, a consequent eepening of color exists. If a tuber be dis-ised, and the base of the pendulum sound, it will e found upon examination, that the disease was caused y some external violence,—such as a bruise, or the ark and cuticle excoriated by an insect or an absolute ecomposition of the skin by lying in water. Each or e whole of these causes combined may destroy the iber, and that at any time under the same circumstan-es. But these are local diseases, and have no connex-on with the one I am treating of; and I name them re in order that they may not be mistaken for the dis-ise that has been so fatal in the present year.

CHAPTER VI.

XAMINATION OF EIGHT PLANTS INCLUDING STEMS, PENDULUMS, AND TUBERS—THE SIZE OF EACH TUBER, AND WHETHER SOUND OR DISEASED, &c.—THE TUBER A MERE RECEPTACLE.

THE eight following plants were taken from the ound October 22nd, 1845, and examined the same ght.

First Plant—White Regent Potato.—Stem with four tubers attached, the tubers attached to the foot-stalk by a separate string.—Single Series, Plate 3.

First or Upper Tuber.—Small but sound, the string also sound; size of tuber 1 inch in diameter.

Second, or next Tuber.—Large, full-sized, but unsound; size of tuber 2 and $\frac{3}{4}$ inches in diameter. The string diseased at its junction with the tuber, but sound 3-4ths of its length towards and at the stem; the tuber diseased over $\frac{1}{2}$ of its circumference immediately beneath the bark or skin and in the empty cellular tissue. The parts of the tuber adjoining the string were the most diseased and those farthest from it, the least so. The eyes in the affected parts of the tuber diseased, and the disease striking inwards through the channels of the germes.

Third Tuber.—The string of this tuber very long—(10 inches,) and quite sound through its entire length; the tuber also sound in every part of it. Size of the tuber 1 inch and 3-4ths in diameter.

Fourth Tuber.—String diseased and dark colored; the whole of the tuber diseased. Size of tuber 1 and $\frac{1}{2}$ inch in diameter. This tuber had thrown out a second string in the part beneath and immediately opposite the one by which it was attached to the foot-stalk. The bottom string had rotted off, and the tuber was most diseased in that part. At the junction of the upper string; it was also considerably diseased.

The stem of this plant was quite sound; the bark of

e part that had been buried in the earth was of the ual brown color observable in roots so circumstanced. o insect or fungi discoverable in any part of the stem, rings, or tubers, by a power of 800 diameters. A w dark brown spots of opaque matter were observed the cells of the medulla, something in appearance like e mass that forms the germe. The cells were perfect.

Second Plant—White Regent Potato.—Stem th a single series of strings, like plate 3, containing ur tubers, one tuber 1 and $\frac{3}{4}$ inches diameter, the other ree varying from 1 and $\frac{1}{2}$ to 1 inch.

First Tuber.—One inch and 3-4ths diameter; tuber sound except at the junction of the string, where the disease had just made its appearance.

Second Tuber.—One inch and $\frac{1}{2}$ in diameter; tuber and string sound.

Third Tuber.—One inch in diameter; tuber and string sound.

Fourth Tuber.—One inch in diameter; tuber and string sound; the stem perfectly sound. The string of these tubers were all thrown off from the roots of the plant, and not from the stalk as is more generally the case.

Third Plant— White Regent Potato.—Stem ntaining one tuber only, size of tuber 1 and $\frac{1}{4}$ inch in ameter. Diseased all over beneath the outward skin epidermis. The empty cellular tissue much dissed, and the cells around it containing fecula dissed also; the centre of the tuber not affected, but disease fast spreading towards it on all sides by ans of the vessels running between the walls of the

cells and those of the germes ; the string diseased but only at the base where it was attached to the tuber; stem quite sound in all parts of it.

FOURTH PLANT—WHITE REGENT POTATO.—Stem and 3 tubers, with a single series of strings.

First Tuber.—One inch and $\frac{1}{2}$ in diameter. Tuber quite sound in all parts of it except at the juncture of the string. The string itself sound, except at the part immediately attached to the tuber.

Second Tuber.—One inch in diameter ; tuber and string sound.

Third Tuber.—Three quarters of an inch in diameter ; tuber and string sound; stem perfectly sound.

FIFTH PLANT.—WHITE REGENT POTATO.—Stem and 2 tubers—

First Tuber.—Three inches in diameter. Tuber diseased all through the cuticle and empty cellular structure, the disease penetrating towards the centre ; the eyes very much diseased ; the disease progressing inwards by the vessels of the germes; the string much diseased, but chiefly at the parts next the tuber ; the disease was spreading itself upwards through the string to the foot-stalk, but it had not reached it.

Second Tuber.—Half an inch in diameter. Tuber sound except at the part of the pendulum, to which it was attached, where the disease had commenced in the empty cells and cuticle. The tuber and string, however, appeared sound out-

wardly, and the disease could only be detected by dissection; the stem quite sound.

SIXTH PLANT.—WHITE REGENT POTATO.—Stalk with one tuber; size 1 and $\frac{1}{4}$ inch in diameter. Tuber and string diseased; stem sound.

SEVENTH PLANT.—WHITE REGENT POTATO.—

First Tuber.—One inch in diameter; tuber diseased three-fourths of its circumference, in the cuticle and empty cellular structure. The disease commencing at the base of the string which was also affected.

Second Tuber.—Three-fourths of an inch diameter; tuber and string quite sound. The stem of this plant was composed of seven pieces, springing from the same root, all of which were quite sound. The leaves were fresh and green on some of the pieces of the stem, while on others they were dying away, and in some places they were dead. The decay of the leaves appeared such as might be expected to take place at the season of the year in which the plant was taken from the ground,—viz. 22nd October.

EIGHTH PLANT.—YORKSHIRE RED POTATO.—(ROUND KIND.)—Single stem with a continuous series of 3 tubers and 4 pendulums—*See plate* 4.

First Tuber and String.—Quite sound; size of tuber 2 and $\frac{1}{2}$ inches in diameter.

Second Tuber.—Size 1 inch and 3-4ths in diameter. The tuber diseased at the juncture of the lower part of the string 2 *b*—*See plate* 4. The

disease, however, had but recently commenced, and was confined to the lower part of the pendulum 2 *b*, in the plate. It was spreading itself through the cuticle 2, and empty cellular texture 3, plate 1. The cells containing fecula not affected.

Third Tuber.—Size 1 inch diameter; tuber diseased over 3-4ths of its circumference in the cuticle and empty cellular tissue. The string diseased especially at the lower part—*see 3 c, plate* 4, to which it was attached. The lowermost string, 4 *d*, plate 4, was completely rotten, and the disease had commenced in the tuber at the part where the pendulum sprung from; this tuber was most diseased at the juncture of the pendulums, and more so in the parts attached to the lowermost string, 4 *d*, plate 4.

From the foregoing experiments, certain facts have been elicited, which may be arranged as follows:—

First.—That in a continuous series of tubers, those farthest from the stem are the most diseased and those nearest to it the least so.

Secondly.—That the tubers, when diseased, appear to be invariably so at the lower part of the string to which they are attached.—*See plate* 4. 1 *a*, 2 *b*, 3 *c*; and this occurs in a single as well as a continuous series.

Thirdly.—That the disease communicates itself by means of the cuticle, the empty cellular structure, and vessels of the germe, 3, 4, 5, plate 1.

Fourthly. That the tubers and strings may be diseased without the stem being affected.

It is a general opinion among phytologists that the tuber is a mere receptacle without any means of outward communication. This opinion, I conceive, to be well-founded and borne out by the following experiment :—

I selected, what from its outward character appeared, a sound tuber, with an equally sound pendulum attached to it. I cemented the end of the pendulum in a glass tube, 40 inches in length, and so arranged it, that I could fill it with any liquid at pleasure. The end of the pendulum was inserted about 1 inch in the tube, and great care was observed in cementing it in, so that the upper surface was left free, and the skin of it uninjured. Thus arranged, with means for the air to escape from the tube, I filled it with a column of water tinged with sulphate of indigo, and left it suspended for 38 hours, when I examined it.

On examination, I found the tuber quite dry all over its surface, and the pendulum equally as dry. As there was no appearance of the liquid having even passed into the pendulum through any of its vessels, I cut the lower part of the tuber off, and left it again suspended for 34 hours longer, when I cut the tuber off and examined it. On dissecting it, the vessels of the pendulum, as well those of the tuber, were found free from the liquid,—and the tuber and pendulum quite sound.

This experiment appeared conclusive as to the tuber being a mere receptacle, and it also showed that even

when the tuber was cut, no channels appeared open for the passage of a liquid, even though under pressure.

CHAPTER VII.

ORIGIN OF THE DISEASE—ITS NATURE AND ACTION CONSIDERED.

In considering the cause of the disease, it will be necessary to condense the facts that I have collected, and present them to the reader in this chapter.

This object may be conveniently attained by arranging them under two heads, viz., Chemical and Microscopical.

Under the chemical head, I will present, first, the facts, and then the inferences deducible from those facts, and avoid as much as possible all theory and speculation on the subject. The microscopical head will contain all the observations made by the eye with and without the aid of the microscope, and the inferences deducible from them. From the chemical and microscopical inferences combined, I propose to show the cause of the disease itself.

The chemical facts may be stated as follows :—

First.—The disease causes a decomposition of the albumen, the azotized constituent of the potato.

Secondly.—The atmosphere colors the potato by means of its oxygen.

Thirdly.—That the brown color of the potato is deepened by alkalics if oxygen be present, but that alkalics alone do not produce it.

Fourthly.—That a healthy potato is acid, a diseased one alkaline.

Fifthly.—That in the decomposition of a diseased tuber the only alkali that can be formed is ammonia.

Sixthly.—That as ammonia is the only alkali that can be formed, the alkaline state of a diseased tuber is owing to its presence.

Seventhly.—That the production of ammonia is caused by a putrid fermentation induced by the albumen of the potato.

Eighthly.—That the black and brown color of the potato is caused by the absorption of oxygen and the presence of ammonia.

Ninthly.—That the starch in the fetid tubers is uninjured, and may be recovered ; and that for all purposes (color excepted) it is as valuable as that produced by the sound tubers.

Tenthly.—That the fecula and ligneous fibre are insoluble in the water of the tubers, and that the sugar, gum, albumen, potateine, and coloring are soluble in it.

Eleventhly.—That the soluble constituents disappear, and the insoluble remain.

Twelfthly.—That the preservation of the starch and ligneous fibre is owing to their insolubility in the water of the tuber.

Thirteenthly.—That the inorganic constituents suffer no change.

Although the starch in diseased tubers may be recovered, even when the tubers are fetid, yet it must be observed, the starch itself would disappear after a lengthened attack of the disease. It would therefore be imprudent to allow known diseased tubers to continue in that state, and risk the loss of the whole of the fecula. The safer plan is, to secure the starch as soon as it can be conveniently accomplished after the disease has been discoverd in any affected tubers.

The inferences deducible from the brief summary that I have made of the chemical results are :—

First.—That putrefaction is the cause of the decay of the tuber.

Secondly.—That the dark color of a diseased tuber is owing to the oxidation of its coloring matter, and the presence of ammonia.

I need not insist upon that which is well known,—such as the ready decomposition of azotized matter, and the formation of ammonia from its decomposition; the oxidation of the coloring principle of plants, the cause of the color being sensible to us, and a variety of other well understood changes. It is sufficient for my purpose to present the facts, and infer from them,

that which is fairly deducible in as short a space as I can.

MICROSCOPICAL OBSERVATIONS, SUMMARY OF.

First.—In a continuous series of tubers the disease commences at the extremity of the pendulums.

Secondly.—The pendulums when diseased are always so at the juncture of the tuber they have nourished and supported.

Thirdly.—That the tubers and pendulums may be much diseased, and yet the foot-stalk remain sound.

Fourthly.—In a single series of tubers the disease commences at the lower part of the pendulum to which the tuber is attached, or immediately in its neighbourhood.

Fifthly.—That the disease commences beneath the bark or epidermis in the cuticle and empty cells, and that it may spread itself by two channels.—first, by vessels 1 and 6, and secondly, by those 3, 4, and 5, plate 2.—

Sixthly.—That the tuber is a mere receptacle or warehouse for storing the productions of the plant, and possesses no channels of outward communication.

Seventhly.—That a tuber may be outwardly sound and internally diseased, and therefore, the external appearance is no indication of soundness.

Eightly.—That no insect or fungi can be perceived in diseased tubers by any means the microscope affords.

From the foregoing observations, I draw the following inferences :—

First.—That the disease commences in the pendulums.

Secondly.—That the pendulums first attacked are those farthest from the foot-stalk if the series be continuous ; and if not continuous, at the part farthest from the stem, and to which the tuber is attached.

Thirdly.—That the pendulums disease the tuber.

Fourthly.—That the disease is not caused by fungi or insect.

The inferences deduced from the microscopical observations are such as the facts themselves warrant; or rather they are the facts condensed, than inferences deduced from them.

I have shown that the tubers and pendulums are diseased, while the parent stem remains sound ; I have also shown that the disease itself is a putrid disease, and that the decomposition of the tuber is attributable to it. I have, therefore, now to trace the primary cause of the disease, or the course of events that produced it.

The potato plant is composed of a stem and appendages, roots, string or pendulums, and tubers*.

The roots, pendulums, and tubers are buried in the soil in which the plant exists. The roots, fix the plant in the soil and convey through their vessels to the

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* There are other parts, botanically considered, which need not be stated here.

stem and leaves, water holding in solution lime, alumina, potash, and the other inorganic constituents shown in the analysis. The leaves inspire from the atmosphere carbonic acid and nitrogen. The carbon and nitrogen received by the leaves and the water, and inorganic matter from the soil, are formed by the living powers of the plant into those substances which its natural organism is arranged to elaborate. The substances thus elaborated in the leaves are carried down to the tuber, and there deposited. From this brief statement of the functions of the plant, combined with the chemical and microscopical inferences already deduced, I shall endeavour to trace the origin of the disease.

To illustrate my subject, I take a plant containing a continuous series of three tubers and a fourth pendulum, as shown in plate 4; 8th plant examined. I suppose a time when the pendulums, tubers, and stem were sound, and from that time I take my datum for the commencement of the disease. In the examination of that plant I find the disease commences at the pendulum 4 *d*, the one the farthest from the stem, and that it commences after heavy and long continued rains. We have here, then, two things.—

First.—That the disease commences at the part the farthest from the stem.

Secondly.—That it appeared after heavy and long continued rains.

These points may be considered under one head. Is the disease primarily induced by too much mois-

ture ? And if so, what facts support this view of the subject?

The facts that favour this view of the subject are the organism of the plant, its constituents as shown by analysis, and the circumstances in which it was placed.

The roots of a plant are stimulated by water to take up inorganic substances for its support, and to enable it to elaborate such principles as its organism is fitted to produce. A plant, therefore, like an animal, may be destroyed by repletion; or it may have too much of one kind of food, and too little of another, and either extreme may prove fatal. The tuber of the potato elaborates nothing; it merely arranges and stores what the plant has formed for it. Even its own organism appears made for it, as the organs it contains are merely a prolongation of those already existing in the superior parts of the plant. The tuber then is a storehouse, and receives such things as are sent down to it from its parent stem, to be deposited in its keeping. It is a passive instrument governed by the plant, and has no power to elaborate anything. Place a potato plant, therefore, in such a condition as the tribe have been placed in this season, and the results that have so generally appeared, must necessarily ensue. Because—

First.—The plant, under the influence of the rain, when it first appeared, formed numerous pendulums and tubers; these tubers and pendulums, it ceased to supply in consequence of the excessive and long continued rains, which gorged it with water, and prostrated its powers.

Secondly.—The newly formed pendulums and tubers were thus left unsupported by the plant, and when the living principle ceased in them a chemical one commenced.

Had the tubers been fully developed, they might for some time have withstood the circumstances in which they were placed; but they were in many cases mere germes, and in others but partly formed, and in all instances where the disease had attacked them, the pendulums had not fulfilled their office, but were in a condition to transmit to the tubers the constituents formed by the plant. During the greater part of the long and excessive rains, the pendulums and tubers were placed in a position most favorable to be destroyed; for they were left to their own resources unsupported by the plant. Placed in such circumstances, and having no powers of conservation in their own structure beyond that of a mere receptacle, and the living powers of the plant having ceased to act on them, a chemical one necessarily commenced; and it commenced at the part where, under the circumstances of the case, it might rationally be expected to commence; viz.—in the pendulum at the juncture of the tuber. Through the small string or pendulum all the elements of the tuber are passed into its keeping. A condensation, therefore, of the constituents naturally exists at this part.

The pendulum is also more susceptible to external influence than the tuber; consequently the azotized body albumen, being more condensed in the pendulum, and more susceptible to external action there, after the disease commenced, than when secreted in

the tuber, was sooner decomposed; and thus we find the decay in all internal cases of disease traceable to the part of the pendulum attached to the tuber, The disease once commenced, it necessarily spread very rapidly under the favorable circumstances in which the tubers were placed for its development. The nature of the action to which the disease is attributable is even, under ordinary circumstances, rapidly fatal to all organic substances; but in the case of the potato, the situation of the tubers favored and increased its activity*.

From the circumstances that have been considered the disease appears to have arisen primarily—

First.—From too much moisture,—the effect of long continued rains, which

Secondly.—Stimulated the plant beyond its ability, and then overpowered it.

Thirdly.—The plant formed more pendulums and tubers than it could support, which

Fourthly.—Being left to themselves, putrified; surrounding circumstances being favorable to their decay.

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* I have shown that the pendulum farthest from the stem, in a continuous series, was always the first attacked. This circumstance coroborates the conclusion as to the want of supply from the stem being the primary cause of the decay in the pendulums and tubers

CHAPTER VIII.

'HE DISEASE MIGHT HAVE BEEN PREVENTED BY TRENCHING — THE GROUND — HOW THE STORED TUBERS MAY BE PRESERVED, AND THE FUTURE SEED ALSO — THE DISEASE NOT NEW.

THE disease has been more fatal on heavy than on ight land. The substratum of heavy land prevents the 'ater from running off, or percolating through it quickly, hile that of light land permits its escape more readily.)iseased tubers, however, may be found on both light nd heavy land; but where found on light soil circum-tances will not be wanting to account for their appear-nce, and which. upon enquiry, will be fonnd to be ex-essive moisture.

I have stated that the plant was first stimulated by the ain and afterwards overpowered by it, and that it thus ormed more pendulums and tubers than it could support; hat the tubers thus left were soon affected with putridity in onsequence of the vitality of the plant being suspended. lthough the powers of the plant were suspended, yet it oes not follow that it might not have recovered itself if laced in a position favourable to do so. But this ex-remity might have been prevented, had the roots and ubers been relieved from the excess of water that op-ressed and destroyed them. The roots of the stem, anp

the tubers of the plant are intermingled in the soil, the roots striking somewhat deeper than the tubers.

If, when the rain had commenced, or even after it had continued for some time, the ground had been well trenched to the depth of some 12 or 14 inches, the whole plant would have been relieved and the tubers saved; for as too much moisture was the primary cause of the disease, so trenching would have prevented it, by carrying off the excess of water that induced the epidemic. Many tubers are externally sound but internally diseased; the appearance, therefore, is no indication of soundness; for the bark, or epidermis, may be perfect, while the cuticle and empty cellular tissue and the generative parts, may be considerably diseased. In storing tubers for winter use, certain conditions should be observed, or the tubers may decay before the disease is outwardly perceptible.

These conditions are:—

First.—Absence of moisture.

Secondly.—Plenty of air—a current passing between the tubers is the most efficacious as it dries their surfaces.

It is of no moment in what way these conditions are complied with, so long as they are observed and maintained in some form. I would recommend that the tubers be laid in layers, placing between each layer straw and wood, or any other substance by which a current of air may be passed through the layers and between the tubers. I would have extended heaps rather than thick ones, and avoid a close atmosphere. The tubers ought not to be placed in pits, and covered with earth, or shut out from the atmosphere. Potatos of this season

are not to be trusted to pits, or to any of the old modes of storing, for the outward appearance is deceptive and no criterion of soundness.

Sand, lime, and other substances have been recommended to be used as a medium in which to store tubers, but I would say, avoid them and trust to the atmosphere. A current of air will always carry off moisture from a damp or wet substance, but sand and lime will not do so; on he contrary they will, although dried before use, soon absorb and retain a portion of moisture natural to them when exposed to the atmosphere at certain temperatures. But the evil rests not there, they prevent the escape of ater from the tubers, and maintain a temperature around hem favorable to the spread of the evil they were inended to prevent.

Stored potatos should be frequently examined, beause although the putrefactive fermentation may be hecked by the means suggested, yet decay silently proeeds in another form if the tuber be diseased. Instead the tuber becoming pulpy and alkaline, as is the case a putrid state, we have the following phases presented—

1. The tuber is quite dry on the external parts of it, d of a dark brown color. 2. It feels hard and firm, d apparently uninjured except superficially. Upon tting the potato open, we find a disease extending itself rough all parts of the tuber, marked by a brown lored mass that is coriaceous or leather-like in its ture, and acid in its action on litmus paper.

In selecting tubers for seed, great care should observed, all the bruised and brown skinned ones uld be rejected, and those only taken that are clean l healthy in appearance. If cuttings be used, all that

have brown spots in them are to be refused, and if a suspicious or doubtful one presents itself, cut it open and examine it. The examination will occupy time, but it will afford security and impart knowledge that will be useful and important to the possessor of it.

In selecting cuttings take none that have the slightest brown speck in them, or that are stained beneath the skin of a brown color, and if cuttings must be taken from a diseased or suspicious tuber through necessity, cut the brown part away with at least half an inch, if possible, of the white and sound part of the tuber with it. The sooner the seed is selected the better, and where cuttings are made, dip the cut parts immediately the cutting is made into dry plaster of paris, which will unite with the water that issues from the cells, and form a dry coating over the surface of the potato, that will tend much to preserve it from decay.

With the exception of the extent of its ravages, the disease of the present season has no characteristic that marks it as new. A variety of opinions have been given as to the cause of it, some attributing it to this, and others to that cause, and cases have been cited in support of the respective views entertained.

My opinions have been formed for me by the results of my own experiments, and the microscopical and other examinations that I have made, and not from any preconceived notion that I entertained of the disease. I commenced the enquiry with my mind a blank upon the subject, and I have spared no pains to prevent error and self-deception.

The knowledge of a disease is said to equal half its cure; I will, therefore, make a few remarks upon

the opinion, that the cause of the potato disease is attributable to cryptogamic fungi and insect. Which of the twain it may be, no decided opinion is, I believe, entertained on the subject, in consequence of the difficulty of distinguishing the insect on the one hand, and the seeds of the fungi on the other, I will therefore suppose it to be both an insect and fungi in order to meet both cases at once. The advocates of cryptogamia all concur, that the stalk of he plant is first affected, and that it is in consequence f insect or fungi; that one or both descend through the essels of the cuticle to the tuber, and there deposit hemselves. And thus the disease commences in the uber.

In the first place I would observe, that the medulla of ne stem is full of cellular tissue of the same kind and haracter as those in the tuber, that when the stem is reen and the tubers forming, its cells are full of fecula ut when the plant has arrived at maturity, they are npty. No doubt can be entertained that the fecula is rmed in the plant, and conveyed to the tuber, but by hat means is not ascertainable, excepting that it goes not rough the cuticle and empty cellular tissues, but either rough the vessels in the walls of the cells, or through e membranes of the cells themselves.

Now all the vessels of the stem are concentrated in e pendulum, and if anything cryptogamic existed, ices of it would be found there. I have, however, arched diligently through all parts of the diseased pendulums, but in no instance have I discovered a trace of her fungi or insect. I have closely examined the stem wnwards, continuing my examination through the dissed pendulums and tubers to the extreme pendulum

with the like effect. But however, for the sake of illustration, I will suppose the cause to be cryptogamic in order to see how far such an opinion is borne out by the facts I have obtained.

A plant lives by assimilating to itself by means of its vessels foreign matter, an insect does the same. It would be difficult, therefore, to conceive how either fungi or insect could propagate and live at the expense of the tuber, and spread through it so rapidly as the disease of the tuber does under favorable circumstances; besides, the large amount of water natural to the potato, is sufficient to support both fungi and insect at any time; how it happens then that a superficial drying of the tuber checks the disease could not be accounted for; were cryptogami the cause. The fungi and insect would continue their work under such circumstances, and the disease advance. Again, in a continuous series of tubers, *see plate* 4, we invariably find the one the farthest from the stem the most diseased, and those next to it the least so, or not at all. Now, in this case, the cryptogami must pass through three pendulums and two tubers to reach the third tuber, upon what principle this can be explained if cryptogamic I cannot perceive, for no insect would travel so much out of its way, and through such intricate passages after the very food it was leaving behind it. The fungi is in the same predicament, it leaves masses of matter in which it might vegetate most luxuriantly to seek others of the same kind in the distance.

If the cause were insect or fungi, the first pendulum and tuber would be affected first, then the second, and so on, but the reverse is the case. Again the foot-stalk is generally sound while the tubers are diseased, this is

another difficulty that cryptogami will not respond to. Upon the whole, then, there is no evidence that the cause is cryptogamic.

But another cause far more alarming than a cryptogamic one has been suggested, and which, if true, would be an evil not easily remedied. It is, that as the life of an individual plant extends to a certain period of years only, it may be worn out unless propagated from the seed, and thus the potato, through the use of the tuber instead of the seed, is in this predicament. Hence the epidemic. The tubers from seed as well as the tubers from sets or cuttings are alike diseased, consequently this opinion is unfounded.*

The disease is such as may always appear, and must from its nature have appeared in many localities before. There is nothing in its character that is not sufficiently accounted for by the circumstances of the case. Thus we have an abundance of moisture, the plant excessively stimulated, and then overpowered, and a chemical action ensuing, first in the pendulums, and afterwards in the tubers. The whole affair is simple and easily explained, and there is nothing mysterious in the matter. From the numerous examinations that I have made, I have little dependence on the tubers of the present season for seed. They are more generally diseased than is at present apprehended, and it will be highly dangerous to use them without first proving them. This may be done and confidence placed in them if the following course be pursued.

Select only the tubers that have a clear and healthy

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* See analysis chap. II.

appearance, and place them in a moist and moderately warm atmosphere, say 60° Fahrenheit. Let them lie in a heap together two or three weeks; examine them frequently, and if any appearance of decay presents itself in any tuber, take it from the heap and reject it. By pursuing this course all the diseased tubers will be developed, and they may be separated from the sound ones. If a diseased tuber be used for seed, the putrefactive fermentation will set in as soon as circumstances favour its development, and destroy the tuber; and this may happen before the germe of the future plant appears, or after it has partially shown itself, but yet not sufficiently so to be independent of the tuber from which it derives its food during the first stages of its infant existence.

In the growth of a potato the germe feeds upon the tuber until it is so far formed as to be capable of supporting itself in the soil, and drawing from thence and the atmosphere the food suited to its organism. Arrived at this stage, it is an independent plant, and the tuber, if any remains, is of no moment, and may be dispensed with; but up to this period of its existence the tuber is of the utmost importance, and unless the germe be supplied with the food fitted for it by nature, it cannot form a plant. A diseased potato, containing the elements of putridity, is therefore unfit for seed, because the tuber may be destroyed by putrefaction induced by the soil in which it was placed for the development and growth of the germe, long before the germe has formed itself into an independent plant. The putrid fermentation proceeds with rapidly fatal strides; so fatal, indeed, that the living principle of the plant could not contend against it with any prospect of success.

The very conditions necessary to be observed for the growth of the seed, are precisely those that favor the putrid action, and the putrid action is more energetic than the living principle. The latter, therefore, would yield to the former, and we might as reasonably expect to "gather figs from thorns, and grapes from thistles," as look for future thriving plants from putrescent tubers.

The general mode of laying out potato fields is bad; no precautionary measures are adopted, and no arrangements made to meet the exigences of either dry or wet seasons, but, alike in the prospect of dry or wet, the tubers are placed in the same circumstances, so far as the skill of the husbandman is concerned, and left to their fate. If the fields, instead of being thus left, were simply divided by trenches into compartments, I have no doubt the present disease would have been warded off, or so far prevented, as to have been comparatively harmless. The potato plant is arranged so as to withstand considerable drought; it has numerous fibres branching from its many roots in all directions; these fibres and roots are constructed to supply [illegible] with water and the necessary inorganic constituents [illegible] the soil, and they are equal to the task upon [illegible], though the weather be for some time continuously dry.

If the husbandman, therefore, guard against moisture, he has [illegible] ar from drought, and this he may do by [illegible] his fields in some advantageous manner according [illegible] nature and situation with but little cost and trouble to himself.

By [illegible] plan he will provide against the contingencies [illegible] sons, and have the satisfaction of knowing that [illegible] d the plant in the most favourable posi-

tion to resist such a disease as the continued moisture of the present year has produced. Let but the tubers and roots of the plant be kept moderately dry, and putrescence, the epidemic of this year, will be unknown. Who ever heard of a putrid potato disease in dry weather? and when has the crop failed through drought? I cannot learn that such things ever occurred, and it is not reasonable they should, for it would be a subversion of natural laws.

The roots of the potato spread themselves about the stem of the plant, and throw forth to a great length fine thread-like fibres; these fibres are very numerous, and they penetrate the soil below the position of the tubers, in search of inorganic matter for the plant. This disposition of the roots is extremely favourable to the preservation of the tubers, and speaks in a language, we cannot misunderstand, as to the means we should employ for the conservation of its products.

The preparation of the ground, therefore, by trenching, is simply to form a few main trunks, the bottom of which should be below the roots, say about two feet deep from the surface of the earth; then with branches about one foot in depth at convenient distances, and we secure the whole plant.

The main trunks relieve the roots from excessive moisture, and the branches the tubers; and thus, should much rain appear, we have placed the plant in a position to protect itself, rather than overpowered it through a want of foresight on our part to guard it agaist contingencies that may always occur.

The plan of trenching not only provides for wet seasons, but improves the quality of the tuber, by permitting

the secretions of the plant to be more leisurely performed. What is the cause of watery and wax-like potatoes? Is it not hasty and ill-formed secretions, induced by the presence of too much moisture, whereby the plant has been too soon and too much excited, and thus eventually weakened in its powers thereby producing ill-formed and imperfect products, and, consequently, bad tubers.

Potato starch may be separated from the tuber in the following manner:—

Fisst—Grind or grate the potato into a fine pulp, put the pulp into a finely pierced sieve, and wash it well with cold water in a tub or vessel. After it has been well washed in the sieve, and repeatedly agitated, pass through the mass remaining in the sieve a current of cold water.

Secondly.—When the starch has fallen to the bottom of the vessel, pour or draw off the clear supernatant-liquid, so far as it can be accomplished without disturbing the starch, and filter the remainder through a flannel or linen filter. After the water has thus been drained from the starch, spread the mass abroad on a board, or metal plate, or some convenient substance, and dry it at a low temperature, say 120° or 130°, Fahrenheit; when dry, the starch is fit for use. The drying may be accomplished in a warm oven or before a fire, if no better means are at hand.

The processes thus recommended are founded on [the] nature of the potato and that of the starch it contains. [T]hus the granules exist in cells, as shown in Plate I. [an]d described in Chapter IV. These cells are composed

of membranes and vessels, that enclose the starch on all sides. By grinding, or grating, the tuber to a pulp, the cells are broken up and the fecula liberated, and as the granules are very small, they are readily separated from the broken vessels of the tuber by washing as directed. The starch being insoluble in cold water is not acted on, and being heavier than its own bulk of that liquid, subsides to the bottom of the vessel used in the operation. As starch gelatinizes at a temperature of 146° Fahrenheit, it is necessary to dry it at a somewhat lower heat to avoid that effect, and therefore 120° or 130° is named.

The flavour of the potato is owing to its potateine, and this is soluble in water. In the diseased tubers the potateine and albumen, and some other of the constituents, are either decomposed, or undergoing that process, and a fetid odour arises in consequence. The starch, however, is seldom injured in the first stages of the disease, and it may, therefore, be recovered by the means recommended, The substances first decomposed are soluble in water, and so also are the remaining products of their decomposition; consequently, the starch may be freed from all that is unpleasant by water, and colour excepted, it is in all respects as valuable as that from the sound tubers.

FINIS.

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